Stellar Dynamics under the Chaining Force:
Three Regimes of Gravitational Competition

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Abstract

We apply the Chaining Force framework — a speculative theory of complexity-driven organization in which matter is driven toward higher complexity over time via the stochastic wave equation $\Box\phi + \frac{2GM}{r}\phi = \tau \cdot \xi(x,t)$ — to the problem of stellar dynamics and migration in the universe. We argue that stars are not passively distributed in space but follow trajectories shaped by the competition between gravity and the Chaining Force. Three distinct dynamical regimes emerge naturally from the equation of motion: a gravity-dominated regime for young structures, a balanced regime for intermediate ages, and a complexity-driven regime for old structures. We show that this framework provides a natural interpretation of stellar accumulation in galaxies, the formation of galactic structure, and the role of supermassive black holes as attractors. Galaxy mergers are interpreted as complexity amplification events. The paper is explicitly speculative and all results are presented as open conjectures.

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1 Motivation

1.1 Stars are not distributed randomly

Stars form in nebulae — clouds of gas and dust compressed by gravity until nuclear fusion ignites. Each star has a precise origin in space and time. After formation, it travels — orbiting the galactic center, moving with its galaxy through the cosmic web, influenced by every mass in its vicinity.

This travel is not random. Stars accumulate in galaxies rather than dispersing uniformly. Galaxies accumulate in clusters. Clusters follow the filaments of the cosmic web. At every scale, structure emerges from what could have been uniformity.

The standard explanation invokes gravity alone: gravity attracts, amplifies small density fluctuations, builds structure hierarchically. This is correct and well-established.

We propose that a second force — the Chaining Force — acts alongside gravity to orient the travel of stellar structures toward greater complexity. The two forces compete, and their competition produces the three regimes described in this paper.

1.2 The Chaining Force equation of motion

The Chaining Force was introduced in Brindel (2026a) via the Lagrangian:

$$\mathcal{L} = \frac{1}{2}(\partial_\mu \phi)^2 - \frac{GM}{r}\phi^2 + \tau \cdot \xi(x,t) \cdot \phi \tag{1}$$

The Euler-Lagrange equation gives:

$$\boxed{\Box\phi + \frac{2GM}{r}\phi = \tau \cdot \xi(x,t)} \tag{2}$$

where:

- ϕ is the complexity field
- τ is the age of the structure
- $\xi(x,t)$ is a stochastic field encoding spacetime curvature along null geodesics
- GM/r encodes the local gravitational potential

This equation contains two competing terms: the gravitational mass term $\frac{2GM}{r}\phi$ on the left, and the Chaining Force source term $\tau \cdot \xi$ on the right. Their relative magnitude determines which regime the structure occupies.

2 Three Regimes of Gravitational Competition

2.1 Regime I — Gravity dominates ($\tau \to 0$)

For young structures, τ is small and the source term $\tau \cdot \xi \approx 0$. Equation (2) reduces to:

$$\Box\phi + \frac{2GM}{r}\phi \approx 0 \tag{3}$$

This is a wave equation with effective mass $m_{\text{eff}}^2 = 2GM/r$. The complexity field oscillates under gravitational confinement. Gravity dominates completely.

Physical interpretation: Young stars and young galaxies fall toward larger masses. They are attracted to the nearest gravitational attractor — larger stars, galactic centers, supermassive black holes. Their trajectory is determined by gravity alone. The Chaining Force has not yet accumulated enough age to compete.

This explains why young stellar populations concentrate near galactic centers and in regions of high mass density.

2.2 Regime II — Balanced competition (intermediate τ)

For intermediate ages, both terms are comparable. The full equation must be solved:

$$\Box\phi + \frac{2GM}{r}\phi = \tau \cdot \xi(x,t) \tag{4}$$

The equilibrium complexity field is:

$$\phi_{\text{eq}}(r) = \frac{\tau \cdot \xi \cdot r}{2GM} \tag{5}$$

and the Chaining Force takes the value:

$$F_c = \frac{\tau^2 \langle \xi^2 \rangle}{4GM} \tag{6}$$

Physical interpretation: Structures find stable orbital configurations. The gravitational attraction is balanced by the complexity-driven tendency to explore and organize. This is the regime of stable stellar orbits, stable galaxies, and long-lived stellar systems like our own Solar System.

The Sun, calibrated at $\tau_\odot \approx \tau_{\text{crit}}$, sits precisely at the boundary between Regimes II and III — old enough that the Chaining Force is significant, not yet old enough to escape gravitational confinement completely.

2.3 Regime III — Chaining Force dominates ($\tau \gg \tau_{\text{crit}}$)

For very old structures, τ is large and the source term dominates:

$$\Box\phi \approx \tau \cdot \xi(x,t) \tag{7}$$

The complexity field is driven entirely by the stochastic Chaining Force. Gravitational confinement weakens relative to the organizing force.

Physical interpretation: Very old stellar structures resist gravitational collapse. They accumulate complexity, develop internal organization, and tend toward higher hierarchical levels. This is the regime where the most complex structures in the universe — advanced stellar populations, complex chemical environments, potentially life — can emerge.

The critical age separating Regimes II and III is:

$$\boxed{\tau_{\text{crit}}(r) = \frac{2GM}{r\sqrt{\langle \xi^2 \rangle}}} \tag{8}$$

3 Stellar Migration and Galactic Structure

3.1 Stars travel toward complexity, not just toward mass

In the standard picture, stars travel under gravity alone — they fall toward mass concentrations. In the Chaining Force picture, old stars also travel toward regions of high complexity — regions where $\tau \cdot \xi$ is large, where other old structures have already accumulated.

This produces a self-reinforcing process:

1. Old structures attract other structures via the Chaining Force
2. New arrivals age, increasing their own τ
3. The local complexity field ϕ intensifies
4. More structures are attracted

This is a complexity amplification cascade — analogous to gravitational collapse but driven by the Chaining Force rather than mass.

3.2 Galactic centers as dual attractors

Galactic centers attract structures by two mechanisms simultaneously:

1. **Gravitational:** the supermassive black hole at the center (e.g. Sgr A* with $M \approx 4 \times 10^6\, M_\odot$) provides an immense gravitational potential well.
2. **Complexity:** the galactic center is the oldest and most complex region of the galaxy. τ is maximal there. The Chaining Force is maximal there.

Stars are therefore attracted to galactic centers by both gravity and the Chaining Force simultaneously. This double attraction explains the high stellar density observed in galactic bulges.

Conjecture 1 (Dual Attractor Conjecture)**.** *[Open] In any galaxy, the galactic center acts as a dual attractor: gravitational for young structures (Regime I) and complexity-driven for old structures (Regime III). The transition between the two attraction mechanisms occurs at* $\tau = \tau_{\text{crit}}$.

4 Galaxy Mergers as Complexity Amplification Events

4.1 What mergers are in the standard picture

When two galaxies merge, their stars do not directly collide — interstellar distances are too large. Instead, their gas clouds collide violently, triggering intense star formation (starburst). The two black holes spiral together and eventually merge into a larger supermassive black hole.

4.2 What mergers are in the Chaining Force picture

A galaxy merger is not merely a gravitational event. It is a **complexity amplification event**:

1. Two old structures — each with large τ — interact.
2. The stochastic fields ξ_1 and ξ_2 of the two galaxies superpose and interfere, producing a combined field of higher variance $\langle(\xi_1 + \xi_2)^2\rangle > \langle\xi_1^2\rangle + \langle\xi_2^2\rangle$.
3. The Chaining Force $F_c \propto \tau^2\langle\xi^2\rangle$ increases sharply during the merger.
4. New stars form (starburst) — precisely the observational signature of the Chaining Force amplification.

Proposition 1. *[Speculative] The starburst intensity during a galaxy merger is proportional to $\tau_1 \cdot \tau_2 \cdot \langle\xi_1 \cdot \xi_2\rangle$, where τ_1, τ_2 are the ages of the merging galaxies and $\langle\xi_1 \cdot \xi_2\rangle$ is the cross-correlation of their stochastic fields.*

This predicts that mergers between older galaxies produce more intense starbursts than mergers between younger galaxies — a testable prediction in principle.

4.3 The merger is not a fusion of bodies

A key observation: in a galaxy merger, the stars themselves do not merge. They pass through each other, exchanging energy and momentum but remaining as distinct objects. Only the gas clouds — the "energy carriers" — collide and interact directly.

This mirrors a fundamental principle of the Chaining Force: complexity does not arise from total fusion but from interaction between distinct structures that remain themselves while exchanging energy. Maximum Chaining Force occurs not when everything merges into one, but when two distinct old structures interact without destroying each other.

5 The Light Travel Time and Directed Stellar Travel

When we observe distant stars and galaxies, we see them as they were in the past — the light has traveled for millions or billions of years to reach us. Stars whose light is still en route to us are invisible today; they will become visible to future observers.

In the Chaining Force picture, this light travel time is not merely an observational limitation. It reflects the fact that stellar structures have been traveling — guided by the competition between gravity and the Chaining Force — since their formation. What we observe is a snapshot of structures at various stages of their journey through the three regimes.

Remark 1. *The observable universe grows with time: as light from more distant sources arrives, new structures enter our past light cone. Each newly visible structure represents a system that has been evolving under the Chaining Force equation (2) for its entire history, now finally revealing itself to us.*

6 Open Problems

1. **Starburst prediction:** Does the merger starburst intensity scale as $\tau_1 \cdot \tau_2 \cdot \langle \xi_1 \cdot \xi_2 \rangle$? This is testable against existing merger observations.

2. **Transition radius:** At what galactic radius does the transition from Regime I to Regime II occur? Is it observationally distinguishable from purely gravitational dynamics?

3. **Dark matter connection:** The Chaining Force filaments of the cosmic web may be related to dark matter filaments. Is $\xi(x,t)$ a proxy for dark matter density?

4. **Life as Regime III:** If life requires Regime III conditions ($\tau > \tau_{\text{crit}}$), this provides a constraint on where and when life can emerge in the universe. Is this consistent with the observed distribution of habitable planets?

5. **Milkomeda prediction:** When the Milky Way and Andromeda merge in $\sim$4 billion years, the combined $\tau_{\text{MW}}+\tau_{\text{And}}$ will produce an intense Chaining Force amplification. Can the starburst intensity be predicted from the current ages and stochastic field properties of the two galaxies?

7 Discussion and Scope

This paper is explicitly speculative. The Chaining Force is a hypothetical framework without experimental confirmation. All results are presented as open conjectures derived from the equation of motion, not as established physics.

The central claim is modest: the equation of motion (2) contains, in its structure, a natural description of three dynamical regimes that correspond to recognizable phases of stellar and galactic evolution. Whether this correspondence reflects deep physics or mathematical coincidence is an open question.

We present it as an invitation to theoretical and observational physicists to examine whether the Chaining Force framework can make predictions that distinguish it from purely gravitational dynamics.

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